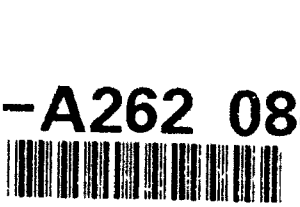

(4)

Final Technical Report
Contract N00014-90-J-1372
January 1, 1990 - Dec. 31, 1992
P.I. Prof. B. N. Parlett
Associated Faculty: Prof. W.M. Kahan

I. Highlights

Prof. W. M. Kahan gave the Turing Award lecture at the annual meeting of the ACM in Washington, D.C. in February 1990. That date falls within the reporting period but we learnt of the award at the end of 1989.

The next pleasant surprise was that Demmel and Kahan were awarded the SIAM Prize for the best paper in Numerical Linear Algebra in a 3 year period at the SIAM meeting in Minneapolis in September 1991. The title was "Accurate Singular Values of Bidiagonal Matrices"

This has also been a very fruitful period for Professor Parlett.

Item (Reduction to tridiagonal form ....) marked the end of the quest begun in 1984 to understand, in full generality, what is called incurable breakdown of the non-symmetric Lanczos algorithm. It turns out that the Canonical Structure theorem for linear time invariant systems (Kahman 1963, Gilbert 1963) gives an elegant explanation of this breakdown as the discovery of a minimal realization of an appropriate transfer function. That means that incurable breakdown is not so bad after all.

The more common obstacle, called curable breakdown, is handled by LookAhead versions of the algorithm. This term was introduced earlier by Prof. Parlett and is now the generally accepted way to implement the Lanczos algorithm.

Now that the algorithm is understood theoretically good implementations are being developed in many groups.

Another long quest that Prof. Parlett completed in this period was to understand the phenomenon of Forward Instability in the symmetric tridiagonal QR algorithm. We now know when and only when this alarming phenomenon can occur. It is invariable associated with premature deflation of an eigenvalue. Through a series of delays the paper was not published until January 1993.

In a completely different view Prof. Parlett, and a gifted student Wu-Liang Heng, developed a novel approach to the 2D Ising model problem that arises in Statistical Mechanics. The new method enables us to solve cases close to criticality for n = 30, and even up to 35. Other methods cannot get beyond n = 18 for reasonable costs. This work is only available in technical reports at present. The following lists show that a lot of other commendable work was either published or completed during this period.

Finally Parlett and Kahan would like to thank ONR for providing most of the funding for the one day conference in October 1992 in honor of their 60th birthdays.

(a) Unpublished

- W. Kahan, "Analysis and Refutation of the LCAS", letter, Aug. 1992.
- W. Kahan, "Invalid Operations Deemed Advantageous", notes, Oct. 1992.
- W. Kahan, "Numerical Formats for a Shared-Data Structures", notes, Jul. 1992.
- W. Kahan, "DVDCATAN: Divided Differences of Arctan & Arcsin", notes, Aug. 1992.
- W. Kahan, "Huge Generalized Inverses of Rank-Deficient Matrices", notes, Sept. 1992.
- W. Kahan, "Roundoff in Complex Multiplication", motes, Nov. 1992.

(b) Papers Published in Refereed Journals

- W. M. Kahan, J. Demmel, "Accurate Singular Values of bidiagonal Matrices", SIAM J. Sci. Stat. Comp. 11 (1990), 873–912.
- B. N. Parlett, "A Note on Communication Analysis of Parallel Sparse Cholesky Factorization on a Hypercube" (with F. Gao). Parallel Computing, vol. 16 (1990), pp. 59-60.
- B. N. Parlett, "Symmetric Matrix Pencils" Journal of Computational and Applied Mathematics, vol. 38 (1991), no. 1-3, pp. 373-385.
- B. N. Parlett, "Some Basic Information on Information Based Complexity Theory" Bulletin of the American Mathematical Society, vol. 26 (1992), no. 1, pp. 3-27. (also sent as technical report)
- B. N. Parlett, "Refined Interlace Properties" (with R.O. Hill, Jr.) SIAM Journal on Matrix Analysis and Applications, vol. 13 (1992), no. 1, pp. 239-247.
- B. N. Parlett, "Reduction to Tridiagonal Form and Minimal Realizations" SIAM Journal on Matrix Analysis and Applications vol. 13 (1992), no. 2, pp. 567-593.
- Adam T. Zawilski, "Numerical Stability of the Cyclic Richardson Iteration", Numerische Mathematik, 60 (1991), pp. 251-290.
- Adam T. Zawilski, "Optimal Bounds for Round-off Errors in the Peaceman-Rachford Iteration", Internat. J. Comput. Math., 41 (1992), pp. 169-179.

(d) Chapters in Books (Published)

- B.N.P., "The Contributions of J. H. Wilkinson to Numerical Analysis" in *History of Scientific Computing*, ed. Stephen G. Nash, ACM Press (1990). (no reprints available)
- B.N.P., "Misconvergence in the Lanczos Algorithm" in *Reliable Numerical Computation*, eds. M.G. Cox and S. Hammarling, Oxford Science Series (1990). (no reprints available)
- B.N.P. and J. Le, "QR: Its Forward Instability and Failure to Converge" in *Proceedings of the 1990 Oberwolfach Conference on Eigenvalue Problems in Engineering*, International Series of Numerical Mathematics, Birkhauser Verlag Basel vol. 96 (1991), pp. 177-189.

(e) Technical Reports

- W-L Heng, "Analysis of Projections of the Transfer Matrix in 2D Ising Models", (W-L Heng's master's thesis which Professor Beresford N. Parlett supervised) CPAM-545 (January 1992).
- B. N. Parlett and W-L Heng, "The Method of Minimal Representations in 2D Ising Model Calculations", CPAM-549 (May 1992).
- B. N. Parlett and W-L Heng, "Implementation of Minimal Representations in 2D Ising Model Calculations", CPAM-550 (May 1992).
- B. N. Parlett, and K. Vince Fernando, "Accurate Singular Values and Differential QD Algorithms", CPAM-554 (July 1992).
- B. N. Parlett and Tzon-Tzer Lu, "Minimum Eigenvalue Separation", CPAM-560 (July 1992).
- W. Kahan and J. W. Thomas, "Augmenting a Programming Language with Complex Arithmetic", Report No. UCB/CSD 91/667 (December 1991).

(g) Invited Presentations

- W. Kahan, Turing Award lecture, ACM Annual Meeting, Washington D.C., Feb. 1990.
- W. Kahan, "Exception Handling", Univ. of Michigan, CMU.
- W. Kahan, "Paradoxes in Concepts", ICM Congress, Aug. 1990.
- W. Kahan, "Very Large Computations in 21st Century", Thinking Machines Workshop, Oct. 1990.
- W. Kahan, "Interface between Symbolic and Numerical Computations", IBM Workshop, Oberlech Jul. 29–Aug. 2, 1991.
- W. Kahan,"Misconceptions in Concepts of Accuracy", UC San Diego, May 11, 1992.
- B. N. Parlett, "Reduction to Tridiagonal Form," Univ. of Bielefeld (Germany), Feb. 24 1990.
- B. N. Parlett, "The Forward Instability of the QR Algorithm," Eigenvalue Problems in science and engineering, Oberwolfach (Germany), Feb. 27 1990.
- B. N. Parlett, "Reduction to Tridiagonal Form," Duke University, March 26, 1990.
- B. N. Parlett, "The Lanczos Algorithm," Univ. of Illinois April 21, NIU April 22, 1990.
- B. N. Parlett, "Reduction to Tridiagonal Form and Minimal Realizations," IBM Workshop on Sparsity in Scientific Computation, Oberlech, Austria, August 6-10, 1990.
- B. N. Parlett, "Symmetric Matrix Pencils: Theory and Applications," International Symposium on Computational Mathematics, Matsuyama, Japan, August 30- Sept.4, 1990.

- B. N. Parlett, "Lanczos Algorithms," SIAM Short Course on Large Scale Computations, San Francisco, November 4, 1990.
- B. N. Parlett, "Reduction to Tridiagonal Form and Minimal Realizations," SIAM Mini-Symposium, Control, Systems, and Signal Processing, San Francisco November 8, 1990
- B. N. Parlett, "Large Eigenvalue Problems," Math Dept., San Jose State Univ., April 11 1991.
- B. N. Parlett, "Computing the Partition Function and Free Energy per Spin for 2-D Ising Models in Magnetic Fields," Parallel Eigensolver Workshop, Pac. Northwest Laboratory, Richland, WA, April 26 1991.
- B. N. Parlett, "Tridiagonal Form and Minimal Realizations", "Sensitivity of QR Factorization", SIAM Conference on Linear Algebra, Minneapolis, September 1991
- B. N. Parlett, "Hunting Large Eigenvalues", San Jose State Univ., April 1991.
- B. N. Parlett, "QR under Large Perturbations", Minneapolis, 1991.
- B. N. Parlett, "Differential QD Algorithms", Leuven (Belgium), Aug. 1992.
- B. N. Parlett, "Differential QD Algorithms", Los Angeles, July 1992.
- B. N. Parlett, "Krylov Subspace Methods", Bielefield (Germany), Sept. 1992.

(h) Students and Post-doctorals

- Post-doc: Adam T. Zawilski, 6/90–12/90.
- M. Sc. student: W-L Heng, 1990.
- Ph. D. students: Y-S Feng (1990), David Day, Yao Yang (current).
- Visiting Associate Researcher: K. Vince Fernando, 1992.

(j) Awards

- W. Kahan received Turing Prize, Annual Meeting of the ACM in Wahington, D.C., Feb. 20, 1991.
- W. Kahan and J. Demmel received the SIAM Prize in Numerical Linear Algebra, SIAM meeting in Minneapolis, Sept. 1991.

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